Running head: Assessment of the Tactical Electronic Medical Record

An Evaluation of the Success of the Tactical Electronic Medical Record:

Graduate Management Project

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The purpose of this study was to evaluate the success of the tactical electronic medical record (Tactical EMR) and its ability to improve medical documentation. The study evaluated data collected from medical personnel using the Tactical EMR. The dependent variable used to evaluate success was organization impact and the independent variables were system quality, information quality, usage, user satisfaction, individual impact, unit, rank, duty position, and time with the unit.

An analysis of 135 survey responses revealed that users ranked information quality the highest, followed by organizational impact, system quality, user satisfaction, individual impact, and usage. The results of a multiple linear regression were significant and supported the alternate hypothesis, which stated that the level of success will vary according to the independent variables. Individual impact was found as the only significant predictor for organizational impact. A one-way ANOVA test compared organizational impact scores by demographics and a significant difference was found among time with the unit, particularly with those assigned to the unit 0 to 12 months.

The results provide important feedback regarding the success of the Tactical EMR. It highlights critical areas for further examination and development in order to improve the Tactical EMR and its future implementation.

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Abstract

The purpose of this study was to evaluate the success of the tactical electronic medical record (Tactical EMR) and its ability to improve medical documentation. The study evaluated data collected from medical personnel using the Tactical EMR. The dependent variable used to evaluate success was organization impact and the independent variables were system quality, information quality, usage, user satisfaction, individual impact, unit, rank, duty position, and time with the unit.

An analysis of 135 survey responses revealed that users ranked information quality the highest, followed by organizational impact, system quality, user satisfaction, individual impact, and usage. The results of a multiple linear regression were significant and supported the alternate hypothesis, which stated that the level of success will vary according to the independent variables. Individual impact was found as the only significant predictor for organizational impact. A one-way ANOVA test compared organizational impact scores by demographics and a significant difference was found among time with the unit, particularly with those assigned to the unit 0 to 12 months.

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Ethical Considerations

Throughout the course of this study, no direct patient information or personal information was used. The only identifiers used for this study were unit, rank, duty position, and time with the unit. These identifiers were used to determine if there were significant difference between them and the variables selected in the study. There were no other ethical considerations for this study.

Introduction

There has not been a point in history where the demands on the Department of Defense (DOD) and the scrutiny over medical practice have been more critical than they are today. Three important catalysts that have drawn considerable attention to each are the terrorist attacks of September 11, 2001 and the results of two Institute of Medicine (IOM) reports. Independently addressing the concerns surrounding current military operations or the state of the American healthcare system presents a number of unique challenges. However, when addressed simultaneously, the challenges increase tenfold. The DOD's unique position makes it responsible for addressing the challenges of both military operations and healthcare concerns simultaneously.

Military operations of yesterday, those prior to September 11, 2001, include operations like Desert Storm in Iraq, Restore Hope in Somalia, and the ongoing operations of Joint Endeavor in Bosnia-Herzegovina and Joint Guard in Kosovo. Military operations of today, post September 11, 2001, include operations like Enduring Freedom in Afghanistan and Iraqi Freedom in Iraq. Lessons learned from both the operations of yesterday and today illustrate that the battlefield is no longer symmetric nor is the enemy clearly defined. New doctrine, better technology, and a sharper focus on protecting the military's best asset, the Soldier, Sailor, Airman, and Marine, are required to achieve success on the battlefield of tomorrow. The key to protecting the military's best asset is superior medical care.

The IOM reports indicate that somewhere between 44,000 and 98,000 people die each year because of medical errors. Although the reports do not clearly delineate between military and civilian medical errors, they indicate that medical errors are a problem in any setting and can lower the level of trust in the healthcare system (Institute of Medicine [IOM] (a), 2000). The

Army currently supports approximately 326,750 Soldiers deployed overseas in over 120 different countries (Schoomaker & Brownlee, 2004). Maintaining superior medical care for each Soldier, especially those deployed in austere and harsh conditions, is a monumental task. It is in these conditions that the Soldier's reliance on the medical system is at its highest. Trust between the medic and the Soldier is paramount and involves an uncompromising relationship that encompasses medical care before, during, and after military operations. To improve and maintain trust in the healthcare system, the IOM endorses the use of information technology. Information technology provides a responsive, integrated, and safe healthcare system necessary for providing quality healthcare (Institute of Medicine [IOM] (b), 2001). Like the IOM, the DOD also recognizes the importance of information technology. Information technology is the capstone for the Army's transformation and is the solution for quality healthcare before, during, and after military operations.

Military operations of yesterday challenged the trust in the Army's medical system. The absence and loss of medical documentation during military deployments has prevented the early identification and diagnosis of deployment related illnesses (Rostker, 1999). Such practices are unacceptable for today's military operations. Therefore, in addition to pre and post-deployment screening of Soldiers, the DOD has been developing a tactical electronic medical record (Tactical EMR). A Tactical EMR enables the DOD to enhance point-of-care treatment, establish a longitudinal health record, maintain continuity of care, improve quality of care, improve medical surveillance, and, ultimately, provide superior healthcare.

The first Tactical EMR to be deployed with the Army's conventional forces is the Stryker Brigade Combat Teams' (SBCT) Medical Information System, which is currently deployed and used in the Army's Stryker Brigades. The Tactical EMR currently fielded with the SBCTs is

unique to the Western Regional Medical Command (WRMC) and will serve as a tool to guide the future development and implementation with other units throughout the Army. The primary components of the Western Regional Tactical EMR include the Personal Information Carrier (PIC), the Battlefield Medical Information System-Tactical (BMIS-T), the Composite Health Care System II-Theater (CHCS II-T), the Theater Medical Information Program (TMIP) server, and the Integrated Clinical Database (ICDB) and its server. Together, Madigan Army Medical Center (MAMC), the SBCTs, TMIP, Medical Communications for Combat Casualty Care (MC4), and the Telemedicine & Advanced Technology Research Center (TATRC) have been working as a team to provide a seamless digital healthcare infrastructure for the Soldiers who are supporting today's and tomorrow's military operations (R.L. Barnhill, personal communication, October 01, 2004).

Conditions that Prompted the Study

In March 2003, the 3rd Brigade, 2nd Infantry Division, was the first SBCT to receive BMIS-T. The intent of the initial fielding of BMIS-T was to evaluate its capabilities. The fielding consisted of the PICs and the BMIS-T hand-held devices. To test the "proof of concept" and evaluate the two components, electronic field medical cards were developed and tested to determine if they could be passed through the evacuation chain. In April 2003, the 1st Brigade, 25th Infantry Division was the second SBCT to receive BMIS-T. In addition to BMIS-T, MAMC purchased laptops and desktops for the SBCTs to extend the "proof of concept" test, improve collaboration between MAMC and the SBCTs, and to meet TMIP network certification requirements. These computers were loaded with ICDB web-based software, which enabled the SBCTs to transfer patient notes from their units to MAMC's ICDB database. MAMC also upgraded the BMIS-T hand-held device by installing an injury prevention scorecard and adding

MEDFUSION, a program which enabled a bi-directional information exchange between BMIS-T and ICDB (R.L. Barnhill, personal communication, September 29, 2004).

In August 2003, the U.S. Army Medical Department (AMEDD) Board conducted a test of the Tactical EMR with 1st Brigade and identified a number of issues requiring further development. Improvements were made; however, not in time for 3rd Brigade to fully test their system before deploying to Iraq. In October 2003, 3rd Brigade deployed with updated, yet untested, equipment to operate the Tactical EMR. From October 2003 to October 2004, 1st Brigade used the Tactical EMR in garrison and during operations at the Joint Readiness Training Center. In spring 2004, the operating system for CHCS II-T was upgraded to Windows 2000 and the system was revalidated. In October 2004, 3rd Brigade redeployed back to Fort Lewis and 1st Brigade deployed to Iraq. 1st Brigade deployed with more training and with the latest upgrades to the Tactical EMR (R.L. Barnhill, personal communication, September 29, 2004).

The Army's proposed architecture for the Tactical EMR starts with data collected at the point-of-injury (Figure 1).

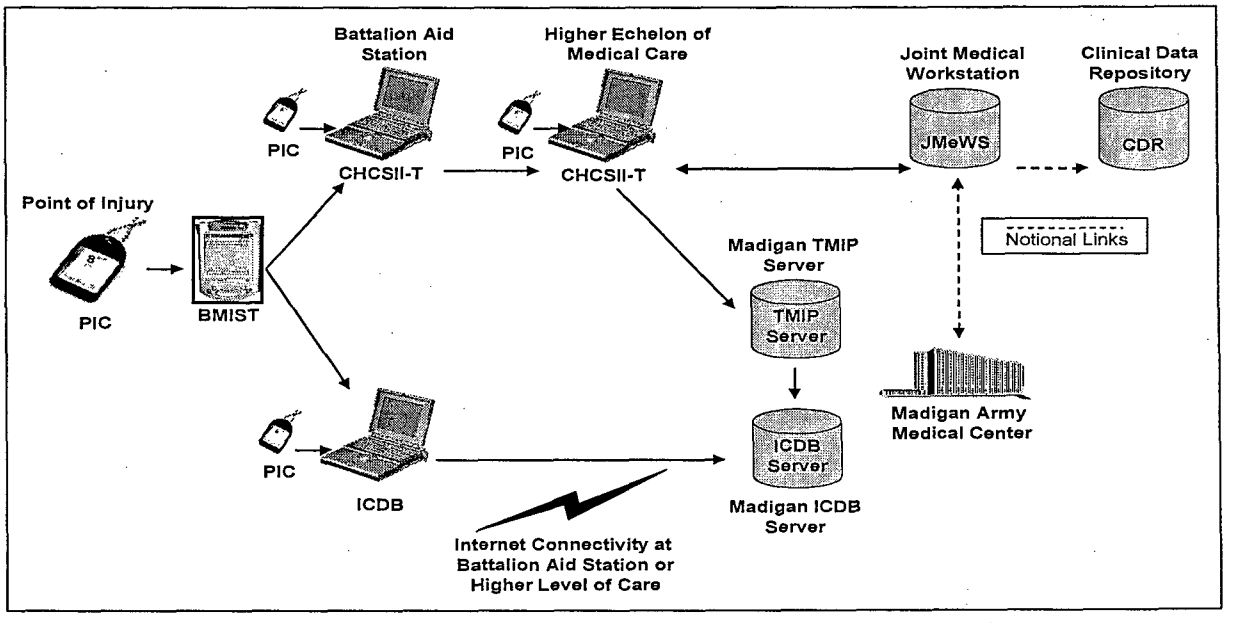

Figure 1. Data Flow for the Tactical Electronic Medical Record

The Soldier's PIC is inserted into the BMIS-T hand-held device and patient care is documented and saved on both devices. Information is then uploaded from the BMIS-T hand-held into a CHCS II-T laptop at the battalion aid station (BAS) or brigade support medical company (BSMC). The information will then be forwarded to an interim TMIP database or the Joint Medical Workstation (JMeWS) and then on to a clinical data repository (CDR). Data is transferred at each of the perspective levels through direct data interface between systems, tactical radio, secure internet, or removable media, such as a disk. The intent of the CDR is to store patient data and be accessible by medical facilities equipped CHCS II and Joint Medical Workstation (JMeWS) access. It is envisioned that the data stored on the PIC and in the CDR, will establish a longitudinal health record and make a Soldier's medical information readily available at any echelon of medical care (Roller & Calgani, 2005; R.L. Barnhill, personal communication, March 25, 2005).

Due to project development timelines and other technical considerations, the Army is not able to deploy its fully proposed Tactical EMR architecture at present. Individual components are currently being tested and used, but are not fully integrated into one consolidated architecture. The Tactical EMR being tested in the Western Region is a variation to the Army's proposed architecture. It capitalizes on a combination of elements from both the Army's architecture and systems currently in use at MAMC. The Western Regional Tactical EMR enables components of the Army's architecture to be evaluated and it provides the Stryker Brigades with the tools necessary (i.e. ICDB) to establish a Tactical EMR for their Soldiers.

The Western Regional Tactical EMR operates similar to the Army's proposed architecture, but it streamlines the flow of information and employs the use of ICDB (Figure 1). The Soldier's PIC is inserted into the BMIS-T hand-held device and patient care is documented and

saved on both devices. Information is uploaded from the BMIS-T hand-held one of two ways: into the CHCS II-T laptop or into the ICDB laptop. If the information is uploaded into the CHCS II-T laptop at the BAS or BSMC, the information is forwarded to Madigan's TMIP server, which then forwards the information directly to the Madigan ICDB server. Data is transferred at each of the perspective levels through direct data interface between systems, tactical radio, secure internet, or removable media, such as a disk. If the information is uploaded into the ICDB laptop, it can be fed directly into the Madigan server through any secure internet connection. Unlike the CHCS II-T data flow, the ICDB connection speeds the flow of information and allows reach-back visibility of all medical data stored in ICDB from the combat theater or garrison. As patient encounters populate ICDB, both garrison and field providers with internet connectivity have access to the most up-to-date medical history for Soldiers receiving medical treatment at the various echelons of medical care (R.L. Barnhill, personal communication, September 29, 2004). To date, there has been little literature to evaluate the success of the Tactical EMR.

Statement of the Problem

The Tactical EMR has been operational for over a year. During this time, the two SBCTs have had the opportunity to thoroughly evaluate the system and identify its strengths and weaknesses. To effectively analyze the success of the Tactical EMR's implementation and its ability to improve medical documentation, it is important to evaluate it from a number of perspectives. One important perspective is to evaluate success from the user or stakeholder perspective. Feedback from the users allows leadership to assess the implementation, dataflow processes, and helps determine if it is meeting user needs. Timely feedback and a thorough analysis of user satisfaction will help identify strengths, weaknesses, barriers, and deficiencies.

Early identification of issues allows leadership to correct problems in a timely manner, provides valuable insight for implementation with other units, and ensures Soldiers continue to receive superior medical care.

In August 2003, an assessment of the Tactical EMR was conducted by AMEDD Board. The assessment evaluated the effectiveness, suitability, and survivability of the system (U.S. Army Medical Department Board, 2003). As part of the assessment, the Board conducted a limited survey to get user feedback. The survey sampled eight people and included only those participating in the assessment. This sample was small and did not accurately represent the current users who are operating in a variety of healthcare environments.

Literature Review

Gulf War illness and its cause(s) has been the subject of much debate over the past decade. The crux of the debate lies with lack of medical documentation, lost medical records, and the inability to determine the root cause(s) of the illness. Roughly 697,000 military personnel deployed in support of military operations in the Persian Gulf and little to no documentation exists to identify: (1) the names and locations of deployed personnel; (2) exposure to environmental health hazards; (3) changes in health status of deployed personnel; and (4) records of immunizations and other health services provided while deployed (Government Accounting Office [GAO] (a), 1997, p. 3). The result is a large number of Soldiers with unexplained medical conditions that are unable to be properly diagnosed or treated. The Presidential Advisory Committee on Gulf War Veterans' Illnesses ultimately concluded that "many of the health concerns of Gulf War veterans may never be fully resolved because of lack of data" (GAO (a), 1997, p. 1).

To identify the medical recordkeeping processes during and after the first Gulf War, the Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses conducted a study. In their study they identified a number of issues that affected medical documentation and medical recordkeeping processes. One important issue identified was military policy, which played an important role in complicating the medical recordkeeping practices. Policies that existed before the first Gulf War were written to support peacetime health services and did not address deployments, especially one as rapid and large-scale as the first Gulf War. Units that deployed found themselves unprepared to deal with the requirements of maintaining health records in a battlefield environment. Throughout the DOD, policies were service specific and recordkeeping practices ranged from units deploying with a portion of the health record, with the entire health record, or with no health record at all. Unclear guidance and questions regarding operational security also confused the issue of documentation for investigational vaccines used during operations. The end results were incomplete, altered, and/or lost medical records (Rostker, 1999).

In 1997, the Government Accounting Office (GAO) was tasked by Congress to review the completeness of Gulf War medical records and to conduct an analysis of medical surveillance procedures completed for Operation Joint Endeavor in Bosnia-Herzegovina, Croatia, and Hungary, 1995-1996. The goal was to determine if corrections had been made since the first Gulf War and to see if health related safeguards were in place to protect Soldiers. Medical surveillance procedures examined in the study were deployment information, environmental health assessment and disease monitoring, medical assessments, and medical recordkeeping. Findings revealed that 24% of personnel did not receive in-theater post-deployment medical assessments, 21% did not receive home station post-deployment medical assessments, and 32%

did not receive a tuberculin skin test. Both the centralized database and the medical recordkeeping processes were incomplete. Medical documentation for in-theater medical assessments, vaccines, and battalion aid station visits were found to be missing in medical records. Two factors that contributed to the results were that service members were allowed to hand carry in-theater medical assessments back to home station and that paper-based records systems were prone to lost or misplaced medical documentation. A recommendation cited in the report to address medical documentation issues was the development of computerized medical records (GAO (a), 1997).

To improve medical surveillance and medical recordkeeping practices, Congress added a provision in the Defense Authorization Act for 1998. The provision mandated the establishment of a medical tracking system for service members deployed overseas as part of contingency or combat operations. Elements of the system would include "use of pre-deployment medical examinations and post-deployment medical examinations to accurately record the medical condition of members before their deployment and any changes in their medical condition during the course of their deployment" (Government Accounting Office [GAO] (b), 2003, p.6). Recordkeeping procedures would include "results of all medical examinations conducted under the system, records of all healthcare services (including immunizations) received by members... and that records of events occurring in the deployment area that may affect the health of such members shall be retained and maintained in a centralized location to improve future access to records" (GAO (b), 2003, p. 7).

In September 2003, the GAO released a follow up report that again evaluated DOD changes and compliance with Force Health Protection (FHP) initiatives. FHP initiatives were designed and implemented to address all health related activities developed to protect the "Total Force"

(Deployment Health Support Directorate, 2003). The GAO report examined the health related activities for deployments supporting Operation Enduring Freedom and Operation Joint Guard and found that among the military installations visited, 38% to 98% of one or both pre- and post-deployment forms were missing for Army and Air Force personnel. Missing immunization documentation ranged anywhere from 14% to 46%, and the centralized deployment record database was found to be missing vital medical information. A review of battalion aid station sign-in logs revealed that 39% of visits to one aid station and 94% to another were not documented in individual health records. The primary reason cited for the missing documentation was that paperwork had been lost somewhere between the theater of operations and the home station. Although the DOD had made important improvements since the Gulf War, the GAO results indicated that the DOD was not completely in compliance with FHP and medical surveillance policies (Government Accounting Office (c), 2003). Noncompliance with these policies poses a serious challenge to the early identification and intervention of future health problems, presents additional challenges to the medical mission, and stresses the foundation of trust between the Soldiers and the military medical system.

The DOD, however, was not operating in a vacuum when it worked to implement improvements in medical surveillance and medical recordkeeping. Three significant events that critically affected DOD operations were the Army transformation and two reports published by the IOM addressing patient safety and the quality of U.S. healthcare. Both events required the DOD to make significant changes in both the practice of warfare and medicine.

The Army's transformation was initiated by the Army Chief of Staff in 1999. The end of the Cold War, an increased threat of terrorism, a growing number of peacekeeping operations, and a need to respond to smaller conflicts prompted a dramatic redesign of the way the Army

conducted military operations. New concepts, capabilities, organizational structures, and doctrine were envisioned to meet the Nation's security challenges of the 21st century. The Army transformation plan involved a comprehensive transition from the Legacy Force, today's Army, to the Objective Force, tomorrow's Army. An Interim Force was introduced as a stop-gap measure to enable the Army transformation to progress efficiently, yet simultaneously allow the Army to respond to the Nation's threats. The Interim Force also provided a well defined group to test and evaluate new concepts, capabilities, and war-fighting doctrine. Lessons learned from the Interim Force would be applied to development of the Objective Force. Fort Lewis, Washington was selected as the test site to field two Interim Brigade Combat Teams or SBCTs (Government Accounting Office (d), 2001). The first SBCT, the 3rd Brigade, 2nd Infantry Division, was projected to be operational in 2003 and the target date for the second SBCT, the 1st Brigade, 25th Infantry Division, was 2004 (Vick, Orletsky, Pirnie, & Jones, 2002).

The SBCTs are so named because the Stryker vehicle is the primary combat and combat support platform used by the units. The units are designed to be lightweight, agile, fast, and prepared for rapid deployment. The SBCT design allows it to engage in a wide array of operational environments, ranging from low to high intensity conflicts. Key SBCT capabilities include: (1) increased operational and tactical mobility; (2) enhanced situational awareness and understanding; (3) combined arms integration down to the company level; and (4) lethal and non-lethal joint effects (Army Transformation (SBCT), 2003). The SBCTs uniqueness stems from the large number of organic units assigned to them. A typical SBCT includes three infantry battalions, a reconnaissance, surveillance and target acquisition cavalry squadron, a brigade support battalion, a field artillery battalion, a military intelligence company, a signal company,

an anti-tank company, and a headquarters company (Army Transformation (SBCT), 2003; Vick, Orletsky, Pirnie, & Jones, 2002).

Medical support for the SBCT is also unique. Combat health support for the SBCTs requires important changes from traditional methods. In addition to a physical redesign of SBCT medical units and their support requirements, medical personnel need to be more proficient and capable of providing patient care in more austere environments. Patient care and medical documentation becomes even more critical and challenging in units that have such a diverse missions like the SBCTs (D.R. Davis, personal communication, September 28, 2004).

Leveraging technology is the key to success for the Army's transformation. This is apparent in the SBCT's ability to see, monitor, and control the battlefield. The advanced technologies employed throughout the SBCTs provide the capability to leverage Command, Control, Computer, Communications, Intelligence, Surveillance, and Reconnaissance (C4ISR) (Army Transformation (SBCT), 2003). Advanced technologies, like the SBCT Medical Information System, deployed with SBCT medical units greatly enhance field medical capabilities, significantly improve the ability to conserve the fighting strength, and reinforce trust in the military healthcare system.

Influencing DOD actions and validating the need for improved information technology and trust are the IOM's two reports, which address patient safety and quality healthcare. The first reports claims that medical errors cause between 44,000 and 98,000 deaths per year. Patients who do not die may be left with significant pain, trauma, discomfort, or dissatisfaction as a result of non-lethal errors. Medical errors can occur in any number of settings and the costs associated with them are both financial and non-financial. Perhaps the most significant non-financial cost is trust in the healthcare system (IOM (a), 2000). Trust in the healthcare system as a whole is

important and should be addressed because as Soldiers transition out of the military healthcare system, they will seek healthcare in civilian facilities, and like the DOD, civilian facilities are just as susceptible to medical record documentation problems and issues.

Dr. Jason Reider (2003) cited a study by Paul Tang in 1994, which identified that paper records were missing in 81% of clinical encounters. Another study stated that doctors were unable to access a patient's medical records for 30% of patient visits. The article further stated that 27% of the time the patient's chief complaint was not recorded in the medical record and 40% of the time the patient's diagnosis was not recorded. Physicians spent 38% of their time writing, dictating, and searching for information in medical records (Hultman, 2002). Bates, Ebell, Gotlieb, Zapp, & Mullins (2003) indicate that "physicians have about 8 unanswered questions for every 10 ambulatory visits" (p. 4). As with the DOD, limited access to patient information results in duplicative care, increased costs, decreased efficiency, and distrust of the health system. System flaws and inefficiencies negatively impact all three aspects of the "iron triangle": cost, quality, and access (IOM (a), 2000).

According to the IOM, the U.S. healthcare system is highly fragmented and in need of a redesign. Redesign of the system includes the use of information technology. "Automation of clinical, financial, and administrative transactions is essential to improving quality, preventing errors, enhancing consumer confidence in the health system, and improving efficiency" (IOM (b), 2001, p. 16). According to Tommy Thompson and Dr. David Brailer (2004), "Health information technology has the potential to transform healthcare delivery, bringing healthcare where it is needed and refocusing healthcare around the consumer" (p. H).

Executive Order 13335, signed by President Bush on April 27, 2004, highlights the importance of adopting the electronic health record (EHR). President Bush's goal is for

"widespread adoption of interoperable EHR's within 10 years" (Thomson & Brailer, 2004, p. A). Interoperability is crucial because competition within healthcare will produce a wide variety of electronic medical record systems. To varying degrees, EHRs are capable of preventing medical errors, conserving resources, reducing variability in care, increasing consumer interaction, and improving privacy. Their full capability, however, cannot be realized until there is interoperability between systems (Thomson & Brailer, 2004).

The DOD is one of the largest healthcare delivery systems within the U.S. and for many years it has used a wide variety of health information technologies to provide services to its beneficiaries. The closed nature of the military health system enables interoperability among many of its medical systems. For example, the Composite Health Care System I (CHCS I) is an automated information support system, which enables physicians to access, store, and query patient information. CHCS I automates many of the healthcare functions required for daily patient care and interfaces with over 40 clinical and administrative systems (Clinical Information Technology Program Office, 2004). System upgrades and improvements have led to the development DOD's newest system, CHCS II. The DOD's experience with health information systems is crucial to supporting the development of a nationwide, interoperable EHR system, especially in rural areas (Thompson & Brailer, 2004).

One method to expand the reach of electronic medical records to rural areas is through the use of hand-held medical devices. Both the DOD and civilian healthcare facilities have recently begun to employ hand-held devices in patient care activities. Hand-held devices have a number of definitions; perhaps the most common name is the personal digital assistant (PDA). Improvements in technology have enabled hand-held devices to support many medical applications. This has allowed medical providers to bring the most up-to-date electronic

information where it is needed most: to the point-of-care (Briggs, 2002). Medical hand-held devices are lightweight, mobile, capable of running a variety of programs (each tailored to user needs), and provide access to electronic drug and medical reference material (Rosenbloom, 2003). Although the interest for hand-held medical devices has grown, few quantitative studies exist that evaluate their performance or impact on healthcare.

Many qualitative studies indicate that hand-held devices save time, improve billing precision, eliminate transcription errors, increase medical documentation, and cut costs. One institution measured their return on investment by the reduction in the amount of paperwork processed (Briggs, 2002; Bird, Zarum & Renzi, 2001). Claudia Tessier of Mobile Healthcare Alliance (2003) stated that, "mobile health care can improve clinical decision making, enhance quality of care, reduce medical errors, improve access and exchange of information, improve accuracy, diminish redundancy, diminish paperwork, increase time spent with the patient, and improve integration" (p. 2). Results from a study on PDAs and point-of-care trauma documentation revealed that the hand-held devices improved the efficiency of daily rounds and eliminated the need for daily dictation. PDAs also reduced the need to write daily notes, which allowed physicians and nurses more time for other patient care activities (Eastes, 2001). Of the literature available, few studies addressed the capabilities of hand-held medical devices and electronic medical records in rural environments.

The DOD's worldwide mission requires it to operate in both rural environments and areas with poor medical infrastructures. This provides the DOD a unique opportunity to evaluate its hand-held medical devices and electronic medical record capabilities in such areas. Issues the DOD must keep in mind when developing and testing these systems are: (1) Force Health Protection initiatives, (2) medical surveillance procedures, (3) Army transformation, and (4) the

need to provide continuous, high quality healthcare for its Soldiers. To address these issues, the DOD combined the capabilities of an electronic medical record and a hand-held medical device to create its proposed architecture for a Tactical EMR. To maximize the potential of the Tactical EMR and test it in real world operations, the Tactical EMR was fielded with the Army's 3rd Brigade, 2nd Infantry Division and the 1st Brigade, 25th Infantry Division. The Tactical EMR fielded to the Stryker Brigades is unique to the Western Region and consists of components of the Army's proposed architecture and systems currently in use at MAMC.

The primary components of Western Regional Tactical EMR are the PIC, BMIS-T, CHCS II-T, the TMIP server, and ICDB. The PIC is an identification tag sized memory device capable of storing an individual Soldier's personal and medical information. It can be carried next to the identification tags and is capable of maintaining a Soldier's complete medical history. All medical encounters, both inpatient and outpatient, can be recorded enabling medical personnel to have the most up-to-date information on the Soldier. As PIC capabilities continue to improve, it will eventually replace the Department of Defense Form 1380 (Field Medical Card) and the Standard Form 600 (Chronological Record of Medical Care). The PIC is capable of interfacing with BMIS-T, CHCS II-T, and ICDB software (Barnhill, 2003; R.L. Barnhill, personal communication, September 29, 2004).

Since its inception, the PIC has undergone a series of revisions and tests. The newer version of the PIC, called the Electronic Information Carrier (EIC), eliminates the need for an adapter and introduces wireless capability. Medics will be able to update and store medical documentation to the EIC without being directly linked. As use of the PIC/EIC increases, medical facilities throughout the different echelons of care will have the capability of viewing

and updating a Soldier's medical history. The first EIC prototypes are expected sometime in late 2005 (Fleming-Michael, 2005).

BMIS-T was originally developed in 1995 by Tommy Morris at the Telemedicine and Advanced Technology Research Center (TATRC) (Fleming-Michael, 2003). "BMIS-T is a lightweight, point-of-care hand-held device that enables healthcare providers to record, store, print, retrieve, and transmit patient encounters" (Telemedicine & Advanced Technology Research Center, 2003, p. 1). Goals of the BMIS-T program include: (1) optimizing patient care; (2) establishing a longitudinal patient record; (3) facilitating medical health surveillance; and (4) developing a point of care hand-held device to improve healthcare by improving medical decision making and reducing errors at the first responder level. BMIS-T extends the reach of the Tactical EMR to the battlefield where the first responders perform combat medicine. In addition to the decision support tools within BMIS-T, the system can also maintain a large library of reference material. Loading BMIS-T with needed medical references eliminates the need of deploying with a large collection of paper references. BMIS-T interfaces with the PIC, CHCS II-T, the TMIP, and MC4 systems. MEDFUSION, a software program developed by MAMC, enables BMIS-T to interface with ICDB (U.S. Army Medical Department Board, 2003; Telemedicine & Advanced Technology Research Center, 2003; R.L. Barnhill, personal communication, September 29, 2004).

CHCS II-T is the theater or field extension of the garrison Composite Health Care System II. CHCS II-T operates in a deployed environment on stand-alone laptop computers. It will allow remote providers to access, document, and store health information at all levels care within the military health system (Thompson and Brailer, 2004). CHCS II-T operates under TMIP, which is "responsible for moving data through tactical communications to a theater wide

database...Data from the theater database will be fed into the military health system's Clinical Data Repository used for non-deployed medical care" (Office of the Assistant Secretary of Defense (Health Affairs) & TRICARE Management Activity, 2004, p. 3).

ICDB was originally developed by Wilford Hall Medical Center as an outpatient clinical support system. The system extracts information from CHCS I and provides clinical data and caseload information for both healthcare providers and administrators. Applications are user-friendly and data is presented through a web-base graphical user interface. Unlike CHCS I and CHCS II, ICDB is accessible through a web browser and is accessible anywhere there is an internet connection. Providers can update patient information in real time and view the patient's complete medical history. ICDB has a unidirectional information exchange with CHCS I, the Ambulatory Data System, and the Clinical Information System and it interfaces with the PIC, BMIS-T, and TMIP server (U.S. Army Medical Department Board, 2003; R.L. Barnhill, personal communication, September 29, 2004).

In September 2003, the AMEDD Board conducted an assessment of the SBCT's Medical Information System or Tactical EMR. The purpose was to evaluate the documentation and data transfer of patient encounters from the point-of-care in a tactical environment through the echelons of medical care to MAMC. The assessment was performed during a brigade communication exercise with the 1st Brigade, 25th Infantry Division. The system's capabilities were assessed in both a tactical and garrison environment. The desired end state for the Tactical EMR was for data to flow from BMIS-T to CHCS II-T, through the TMIP server at MAMC, and on to the ICDB server at MAMC. Once the patient encounter reached the ICDB server, it would be visible for garrison providers at MAMC. At the completion of their assessment, the AMEDD board concluded that the Tactical EMR was not yet suitable and it was ineffective in regards to

the critical assessment issues evaluated. Items addressed under suitability were training shortfalls and equipment shortages. The system was labeled ineffective because "all medical encounters from the company medic, brigade support medical company, troop medical clinic, and MAMC could not be viewed through ICDB" (U.S. Army Medical Department Board, 2003, p. 2-19). The assessment also included a BMIS-T user questionnaire with 19 questions and a desk audit/user opinion survey with 38 questions. The sample size for each questionnaire was eight people and there was no overall analysis of the results (U.S. Army Medical Department Board, 2003).

The AMEDD board's assessment focused primarily on three main components: effectiveness, suitability, and survivability (U.S. Army Medical Department Board, 2003). To evaluate a system's success, one must keep in mind the setting, objectives, and the stakeholders (Van Der Meijden, Tange, Troost, & Hasman, 2003). The AMEDD Board essentially addressed one of the three elements of success: objectives. Kaplan (1997) states that in order to evaluate the impact of medical information systems, "research should be designed to identify, collect, analyze, and interpret data to form a coherent picture of processes that resulted in the effects or impacts" (p. 95). To form a coherent picture of the Tactical EMR, it is also critical to assess the success of the system from the user or stakeholder's perspective.

Information system success is difficult to define, measure, and assess. There is a broad range of literature that both suggests the best way to measure information system success and confuses the issue. In an attempt to reduce the confusion and organize the information surrounding information system success, DeLone & McLean (1992) proposed six categories, which combined, represent a simplified model for information success. The six categories are 1) system quality, (2) information quality, (3) use, (4) user satisfaction, (5) individual impact, and

(6) organizational impact. DeLone & McLean describe their model as a process model with each of the individual categories having an interdependent relationship. System quality and information quality individually and simultaneously have an impact on use and user satisfaction. Use and user satisfaction have a direct affect upon one another. They in turn directly affect individual impact, which then affects organizational impact. To effectively measure success, DeLone & McLean suggest that individual measures from the different categories should be combined "to create a comprehensive measurement instrument" (DeLone & McLean, 1992, p. 88). They also note that other contingency variables should be included, such as the structure, size, and environment of the organization being studied (DeLone & McLean, 1992).

Van Der Meijden, Tange, Troost, and Hasman (2003) conducted a thorough study of both English and Dutch literature to evaluate the framework proposed by DeLone & McLean (1992). Out of 191 articles, 33 articles, describing 29 different information systems, were selected for analysis. The results revealed that "information quality was evaluated in 64% of the studies, system quality in 58%, usage in 36%, user satisfaction in 48%, individual impact in 45%, and organizational impact in 39%" (Van Der Meijden, Tange, Troost, & Hasman, 2003, p. 237). Questionnaires, chart reviews, and interviews were the primary tools used for assessing system quality, information quality, user satisfaction, individual impact, and organizational impact. Usage was assessed through time/work sampling and content analysis. Key attributes of each success factor were also identified. Key attributes for system quality were ease of use, response time, and time savings. Those identified for information quality were completeness, accuracy of data, and legibility. Usage attributes were number of entries, frequency of use, and duration of use. The attributes noted for user satisfaction were user satisfaction itself, attitude, and user friendliness. Individual impact attributes were change of work patterns and direct benefits.

Communication/collaboration and impact on patient care were the key attributes for organizational impact (Van Der Meijden, Tange, Troost, & Hasman, 2003).

Van Der Meijden, Tange, Troost, & Hasman (2003) also note in their study that the primary study designs used to evaluate healthcare information systems were descriptive and correlational designs. Kaplan (1997) adds that when studying medical information systems, it is a good idea to use a combination of quantitative and qualitative methods. Using both strengthens the ability to form a coherent picture of the situation under study (Kaplan, 1997).

DeLone & McLean's framework combined with the key attributes identified by Van Der Meijden, Tange, Troost, & Hasman provide a good format to evaluate the success of the Western Regional Tactical EMR from the user perspective. The overall framework plus the individual attributes together facilitate the creation of a survey in order to establish the "comprehensive measuring instrument" suggested by DeLone & McLean.

Purpose

The purpose of the study was to evaluate the success of the Tactical EMR and its ability to improve medical documentation from the user perspective. Using DeLone & McLean's model and Van Der Meijden, Tange, Troost, & Hasman's key attributes, a survey was designed to collect user feedback regarding the Tactical EMR and to gain critical insight into specific areas users felt needed improvement. The survey also provided user recommendations to help leadership improve the Tactical EMR's development and future implementation.

The variables selected in this study to broadly define success were information quality, system quality, usage, user satisfaction, individual impact, organizational impact, and demographics. The variable selected, more specifically, to evaluate the success of the Tactical EMR and its overall impact on the organization was organizational impact. This fits with

DeLone & McLean's flow of interdependent variables, in which organizational impact was last. The survey questions that address organizational impact, in particular, address the EMR's ability to enhance point-of-care treatment, establish a longitudinal health record, maintain continuity of care, improve quality of care, improve medical surveillance, and, ultimately, provide superior healthcare. Demographics were included to incorporate DeLone & McLean's recommendation of adding contingency variables.

The dependent variable for this study was organizational impact (Y) and the independent variables were system quality (X_1), information quality (X_2), usage (X_3), user satisfaction (X_4), individual impact (X_5), unit (X_6), rank (X_7), duty position (X_8), and time with the unit (X_9). System quality was defined by the variables of ease of use, response time, and time savings. Information quality was defined by the variables of completeness, accuracy of data, and legibility. Usage was defined by the variables of number of entries, frequency of use, and duration of use. User satisfaction was defined by the variables of user satisfaction, attitude, and user friendliness. Individual impact was defined by the variables of change in work patterns and direct benefits. The dependent variable, organizational impact, was defined by the variables of communication/collaboration and impact on patient care.

Due to the interdependent relationship presented by DeLone & McLean and their assumption that each variable will have some affect on organizational impact, the alternate hypothesis selected for the study was that the level of success for the Tactical EMR, organizational impact, will vary according to the independent variables. The null hypothesis was that the level of success for the Tactical EMR would not vary according to the independent variables.

Methods and Procedures

The research method chosen for this project was a cross-sectional, descriptive design that was primarily quantitative with some qualitative analysis (Cooper & Schindler, 2003). A combination of both types of analyses helped "improve the quality of results through triangulation" (Van Der Meijden, Tange, Troost & Hasman, 2003, p. 242) and provided a more complete analysis of the Tactical EMR. Data was collected using a nonprobability, purposive sampling approach of medical personnel assigned to the 3rd Brigade, 2nd Infantry Division and the 1st Brigade, 25th Infantry Division (Cooper & Schindler, 2003). A survey instrument was designed using DeLone & McLean's framework for information system success and the key attributes for each that were identified by Van Der Meijden, Tange, Troost, & Hasman.

The survey was designed in direct consultation with the WRMC Chief of Staff and Chief of Informatics. Their suggestions and guidance helped fine tune each question to ensure useful information could be collected to evaluate the Tactical EMR. After the survey design was complete, the survey was given to the Noncommissioned Officer in Charge (NCOIC) of the 3rd Brigade Surgeon's office. He, in addition to two other medic noncommissioned officers (NCO), reviewed the cover letter and survey to ensure the instructions and questions were readable, understandable, and clear. Their primary concern was that many of the medics who used the Tactical EMR used it sporadically and at different capacities. To ensure that respondents answered the surveys with consistency, the following disclaimer was added to the instructions, "When completing the survey, consider the components of the Tactical EMR and answer the questions according to your experiences using the medical information system when it was available and working." The final survey was approved by the WRMC Chief of Staff.

The survey packet consisted of a cover letter explaining the purpose of the study and instructions on how to complete the survey (Appendix A). The survey contained 29 questions (Appendix B), which were broken down into three sections. Section one contained four questions to collect demographic information. Section two consisted of 25 questions designed to evaluate the success of the Tactical EMR. Each question was ranked using a Likert scale that measured from 1 (strongly disagree) to 7 (strongly agree). Respondents were instructed to answer each question according to how they agreed or disagreed to each given statement. Survey questions 5 through 28 were grouped according to each variable and key attribute being evaluated (Appendix C). Question 29 was a stand alone question to see how the respondents felt the Tactical EMR was progressing. Section three was for any comments the respondents wanted to include.

Before the survey was distributed, coordination was made with the 1st Corp Surgeon's office to ensure they were aware that the study was being conducted. The 1st Corp Surgeon's office approved the study and offered their support. The primary points of contact for each unit were the perspective Brigade Surgeon offices. The NCOIC of the 3rd Brigade Surgeon's office and an officer from the 1st Brigade Surgeon's office served as the central distribution and collection points for the surveys.

Each brigade had approximately 200 medical personnel assigned, which produced a sampling pool of approximately 400 personnel. However, personnel turnover, operational tempo, and training/mission mission requirements affected the number of medical personnel available to complete the surveys. On 12 January 2005, 200 survey packets, which included the survey and cover letter, were distributed to 3rd Brigade. The surveys were collected and returned on 21 January 2005. Due to 1st Brigade's deployment and varying locations throughout Iraq, their

survey packets were forwarded electronically. Survey packets for 1st Brigade were reproduced locally and distributed or forwarded by email to survey respondents on 05 February 2005. They were collected and returned on 11 February 2005. The combined survey response rate was 145 out of 400, or approximately 36% (96 surveys from 3rd Brigade and 49 from 1st Brigade). Of the 145 surveys returned, 10 were removed because survey respondents noted in the comments section that they had never used the medical information system. The remaining sample size was N = 135; N = 90 for 3rd Brigade and N = 45 for 1st Brigade (Table 1). The results from the survey were compiled and then coded for statistical analysis.

Table 1

Demographic Breakdown of Survey Respondents

Unit	Number of Responses	Rank				Duty Position		Time with Unit			
		Enlisted	NCO	Officer	Unknown	Medic	Physician / Admin	0-12 Months	12-24 Months	24 + Months	Unknown
3rd Brigade Total	90	51	32	6	1	84	6	7	36	47	
1/23 IN	7	3	4	0		7	0	0	3	4	
2/3 IN	15	9	3	3		12	3	1	9	5	
5/20 IN	22	14	7	1		21	1	1	7	14	
1/14 CAV	18	10	6	1		17	1	1	9	8	
296 BSMC	17	10	6	1		16	1	1	8	8	
1/37 FA	10	5	5	0		10	0	3	0	7	
18 EN	1	0	1	0		1	0	0	0	1	
1st Brigade Total	45	14	17	12	2	33	12	12	16	16	1
1/25 IN (unspecified)	2	0	0	2		0	2	1	1	0	
1/5 IN	5	1	3	1		4	1	0	4	1	
3/21 IN	8	2	4	2		6	2	1	4	3	
1/24 IN	6	2	1	3		3	3	1	3	2	
2/14 CAV	5	0	3	2		3	2	1	1	3	
25 BSMC	17	8	5	2		15	2	8	3	5	
2/8 FA	2	1	1	0		2	0	0	0	2	
Total Number of Responses	135	65	49	18	3	117	18	38	104	126	1

Note: IN = Infantry; CAV = Cavalry Squadron; BSMC = Brigade Support Medical Company; FA = Field Artillery; EN = Engineer

The survey results provided the foundation for the quantitative analysis and the comments section provided additional insight into what respondents thought about the Tactical EMR. The survey comments, coupled with the information presented at the 3/2 SBCT Tactical e-Medical Record Research and Demonstration Conference, provided the foundation for the qualitative analysis. The conference was the first major forum to bring the Tactical EMR's designers and users together after having the system deployed in Iraq for a year. For two days, a series of presentations addressed concepts, implementation, usage, and after action review comments from all involved.

Validity and Reliability

Validity refers to the "extent to which a test measures what we actually wish to measure" (Cooper & Schindler, 2003, p. 231). The validity of the survey is addressed using both construct and content validity. Construct validity examines the theory and the measurement tool to determine if the selected variables accurately measure the construct being tested. Content validity assesses the extent to which the measurement instrument covers the topic under study (Cooper & Schindler, 2003). In this study, construct validity was addressed by examining how well the independent variables accurately measured success. Content validity was addressed by how well the key factors within each independent variable adequately defined each variable. Both the construct and content validity of the survey instrument were supported by the comprehensive literature review conducted by Van Der Meijden, Tange, Troost, & Hasman (2003). The six variables chosen for the study were validated and identified by them as the primary indicators of success in 29 different information systems. In addition to the six factors, the key attributes for each are also specified and identified in the study. Questions selected for the survey were derived from both the key attributes and survey questions used during the

AMEDD Board visit. The survey was reviewed and validated by the WRMC Chief of Staff, Chief of Informatics, and three NCO medics assigned to 3rd Brigade who had operational experience with the Tactical EMR. The review and feedback from these personnel further improved the construct and content validity of the survey instrument.

To address the "accuracy and the precision of the measurement procedure," reliability must also be discussed (Cooper & Schindler, 2003, p. 231). Reliability in this study was addressed by evaluating the internal consistency or inter-item reliability of the questions that evaluated each variable. Evaluating internal consistency assessed the consistency of the questions asked within each of the variables. A high degree of correlation would indicate high reliability of the questions chosen to measure each variable. Cronbach's alpha, "which has the most utility for multi-items scales at the interval level of measurement," was used to test the inter-item reliability (Cooper & Schindler, 2003, p. 239). According to the UCLA Academic Technology Services "a reliability coefficient of .80 or higher is considered as "acceptable" in most Social Science applications" (UCLA Academic Technology Services, n.d.). All of the items, except usage, which resulted in an alpha = .78, exceeded the .80 threshold indicating an "acceptable" level of reliability (Table 2).

Table 2

Cronbach's Alpha Reliability Scores

Variable	Cronbach's Alpha
System Quality	
Questions 5 through 8	.89
Information Quality	
Questions 9 through 12	.91
Usage	
Questions 13 through 15	.78
User Satisfaction	
Questions 16 through 21	.90
Individual Impact	
Questions 22 through 24	.91
Organizational Impact	
Questions 25 through 28	.92

Analytic Methods

Descriptive statistics were calculated to provide an overview of the characteristics of the data. Mean scores and standard deviations were calculated to assess how survey respondents evaluated the Tactical EMR. Questions that evaluated a particular key attribute were averaged to get a mean score for each. The mean scores of the key attributes were then combined to get an overall mean for the variable they measured. A correlation analysis was conducted to measure the linear association between the variables. A Spearman *rho* correlation analysis was selected because the assumption of normal distribution for all of the variables was not met. An independent-samples *t*

test was calculated to identify significant differences between the units and then the duty positions for each of the variables in the model. A one way analysis of variance (ANOVA) was used to identify significant differences between the rank groups and then time with the unit for each of the variables in the model. If significance was identified, the Fisher's least significant difference (LSD) post-hoc test was used to determine where differences occurred among the groups. Multiple linear regression was used to test the alternate hypothesis that the level of success will vary according to the independent variables. The results of the regression also provided a measure as to whether the model was a good predictor of success (Cronk, 2004; Cooper & Schindler, 2003).

Results

The descriptive statistics for the variables and their key attributes are shown in Table 3 and the descriptive statistics for each survey question are shown in Table 4.

Table 3

Descriptive Statistics for Variables and Key Attributes

Variable	n	Mean	Standard Deviation
System Quality	135	3.31	1.38
Ease of Use	135	3.00	1.45
Response Time	134	3.33	1.51
Timesavings	135	3.57	1.67
Information Quality	135	3.60	1.40
Completeness	135	3.43	1.64
Accuracy of Data	135	3.61	1.40
Legibility	135	3.75	1.60
Usage	135	2.98	1.37
Number of Entries	134	3.45	1.62
Frequency of Use	135	2.80	1.71
Duration of Use	135	2.68	1.65
User Satisfaction	135	3.29	1.35
User satisfaction	135	3.33	1.33
Attitude	135	3.27	1.62
User Friendliness	135	3.27	1.41
Individual Impact	135	3.04	1.40
Change in Work Patterns	135	2.99	1.43
Direct Benefits	135	3.10	1.52
Organizational Impact	135	3.35	1.47
Communication/Collaboration	134	3.28	1.65
Impact on Patient Care	135	3.39	1.45

Table 4

Descriptive Statistics for Individual Questions

Variable		n	Mean	Standard Deviation
Question 5:	Using the SBCT MIS to document patient care...	134	2.95	1.59
Question 6:	Transferring patient encounters between system...	135	3.06	1.52
Question 7:	The SBCT MIS provides the information I need...	134	3.33	1.51
Question 8:	The SBCT MIS improves my ability to document...	135	3.57	1.67
Question 9:	Medical information is more complete because...	135	3.43	1.64
Question 10:	Accuracy of medical information is improved...	134	3.51	1.55
Question 11:	The SBCT MIS provides enough information...	135	3.71	1.48
Question 12:	Information in the SBCT MIS is easy to read...	135	3.75	1.60
Question 13:	The SBCT MIS has enabled me to create...	134	3.45	1.62
Question 14:	I use the SBCT MIS every time I interact with...	135	2.80	1.71
Question 15:	Documenting medical information in the SBCT...	135	2.68	1.65
Question 16:	The SBCT MIS improves medical documentation...	135	2.43	1.56
Question 17:	The SBCT MIS improves medical documentation...	134	4.08	1.69
Question 18:	The SBCT MIS is an improvement over paper...	134	3.49	1.56
Question 19:	The SBCT MIS is worth the time and effort...	135	3.27	1.62
Question 20:	Medical Information stored in the SBCT MIS...	135	3.67	1.69
Question 21:	I use the SBCT MIS more often because...	133	2.83	1.45
Question 22:	The SBCT MIS has made my job/mission easier...	135	2.95	1.50
Question 23:	The SBCT MIS has improved my ability to...	134	3.04	1.54
Question 24:	The increased availability of medical information...	135	3.10	1.52
Question 25:	The SBCT MIS has improved the communication...	134	3.28	1.65
Question 26:	Access to more medical information has improved...	133	3.55	1.62
Question 27:	Using the SBCT MIS has increased medical...	134	3.24	1.52
Question 28:	The increase in medical documentation has had...	135	3.38	1.59
Question 29:	I believe the implementation of the SBCT MIS...	135	3.79	1.72

Note: SBCT MIS = Stryker Brigade Combat Team Medical Information System

As noted earlier, survey respondents were instructed to score questions on Likert Scale of 1 (strongly disagree) to 7 (strongly agree) for given statements. One the whole, all variables were ranked below 4 (neither agree nor disagree) on the Likert scale. Of the five variables selected to evaluate the success of the Tactical EMR and its ability to improve medical documentation, respondents ranked information quality the highest ($m = 3.60$, $sd = 1.40$) and usage the lowest ($m = 2.98$, $sd = 1.37$). Of the key attributes, legibility ($m = 3.75$, $sd = 1.60$) ranked the highest overall key attribute and duration of use ($m = 2.68$, $sd = 1.65$) the lowest. The question with the highest mean score was question 17 ($m = 4.08$, $sd = 1.69$), the SBCT medical information system improves medical documentation in fixed medical treatment facilities. The question with the lowest mean score was question 18 ($m = 2.43$, $sd = 1.56$), the SBCT medical information system improved medical documentation under stressful, fast paced battlefield conditions. Question 29 ($m = 3.79$, $sd = 1.72$), assessed whether users felt the Tactical EMR was progressing in the right direction. Appendix D contains a complete breakdown of descriptive statistics for each unit and Appendix E contains the rankings of each variable and key attribute by demographic category.

A Spearman rho correlation was calculated for each of the variables (Appendix F). A significant positive correlation ($p < .001$) was found between the variables of system quality, information quality, usage, user friendliness, individual impact, and organizational impact. There was a significant negative correlation between time with the unit and information quality, usage, and organization impact at $p < .001$ and between time with unit and user satisfaction and individual impact at $p < .05$.

The independent-samples *t* test was used to compare the mean scores by unit and duty position for each variable. No significant differences were found between the mean scores of 3rd Brigade and 1st Brigade or the mean scores of physician/admin and medic for each variable

(Appendix G). The ANOVA was used to compare the mean scores for the different rank groups and time with unit categories for each variable. The mean score of each variable was compared with the mean scores of the three different rank groups (enlisted, NCO, and officer) and no significant difference was found between the three rank groups (Appendix H). When the mean score of each variable was compared with mean scores of each time group, a significant difference was found among time groups for information quality, usage, user satisfaction, and organizational impact (Table 5).

Table 5

Analysis of Variance for Time with Unit

Variable		Sum of Squares	Mean Square	F	Sig.
System Quality	Between Groups	8.48	4.24	2.29	.11
	Within Groups	242.95	1.86		
	Total	251.43			
Information Quality	Between Groups	18.27	9.14	4.94	.01*
	Within Groups	242.19	1.85		
	Total	260.46			
Usage	Between Groups	29.92	14.96	8.98	.00*
	Within Groups	218.18	1.67		
	Total	248.10			
User Satisfaction	Between Groups	11.25	5.63	3.21	.04*
	Within Groups	229.91	1.76		
	Total	241.16			
Individual Impact	Between Groups	8.68	4.34	2.23	.11
	Within Groups	254.72	1.94		
	Total	263.40			
Organizational Impact	Between Groups	25.68	12.84	6.41	.00*
	Within Groups	262.61	2.01		
	Total	288.29			

Note: df= 2,129; *p < .05

Fisher's LSD post-hoc test was used to examine the differences between time groups. The analysis revealed that individuals assigned to the unit from 0 to 12 months scored information quality, usage, user satisfaction, and organizational impact significantly higher than those assigned 12 to 24 months and 24 or more months (Table 6).

Table 6

Fisher's Least Significance Difference Post Hoc Test for Time with Unit

Variable	Category 1	Category 2	Mean Difference	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Information Quality	0-12 Months	12-24 Months	.75*	.36	.04	.03	1.47
	0-12 Months	24 + Months	1.11*	.36	.00	.40	1.81
	12-24 Months	0-12 Months	-.75*	.36	.04	-1.47	-.03
	12-24 Months	24 + Months	.36	.26	.16	-.15	.86
	24 + Months	0-12 Months	-1.11*	.36	.00	-1.81	-.40
	24 + Months	12-24 Months	-.36	.26	.16	-.86	.15
Usage	0-12 Months	12-24 Months	1.09*	.35	.00	.40	1.77
	0-12 Months	24 + Months	1.43*	.34	.00	.76	2.10
	12-24 Months	0-12 Months	-1.09*	.35	.00	-1.77	-.40
	12-24 Months	24 + Months	.34	.24	.16	-.13	.82
	24 + Months	0-12 Months	-1.43*	.34	.00	-2.10	-.76
	24 + Months	12-24 Months	-.34	.24	.16	-.82	.13
User Satisfaction	0-12 Months	12-24 Months	.60	.36	.10	-.10	1.30
	0-12 Months	24 + Months	.87*	.35	.01	.19	1.56
	12-24 Months	0-12 Months	-.60	.36	.22	-1.44	.24
	12-24 Months	24 + Months	.27	.25	.27	-.22	.76
	24 + Months	0-12 Months	-.87*	.35	.04	-1.69	-.05
	24 + Months	12-24 Months	-.27	.25	.51	-.86	.31
Organizational Impact	0-12 Months	12-24 Months	1.05*	.38	.01	.30	1.80
	0-12 Months	24 + Months	1.33*	.37	.00	.59	2.06
	12-24 Months	0-12 Months	-1.05*	.38	.02	-1.95	-.15
	12-24 Months	24 + Months	.28	.27	.30	-.25	.80
	24 + Months	0-12 Months	-1.33*	.37	.00	-2.20	-.45
	24 + Months	12-24 Months	-.28	.27	.55	-.90	.35

Note: $p < .05$

Of particular note was the significant difference between the time groups and the dependent variable representing success, or organizational impact. Individuals assigned to the unit 0 to 12 months ($m = 4.38$, $sd = 1.33$) ranked success significantly higher than those assigned 12 to 24 months ($m = 3.33$, $sd = 1.25$) and 24 months or more ($m = 3.05$, $sd = 1.56$). There was no significant difference between the means scores of those assigned 12 to 24 months and 24 or more months for any of the variables. On explanation for this may be that users assigned to the units longer had more institutional knowledge and exposure to the Tactical EMR as it was being introduced, fixed, and upgraded. Their experiences with the system may have varied more than newer users who had a more limited frame of reference for comparison and evaluation.

Multiple linear regression was used to test the alternate hypothesis that the level success (organizational impact) will vary according to the independent variables. The results of the regression were significant ($F(9, 122) = 39.22$, $p < .001$), with an R^2 of .74 (Table 7).

Table 7

Regression Analysis for Organizational Impact as a Function of the Independent Variables and as a Function of the Individual Questions

Model	R	R Square	Adjusted R Square	SEE	F	Sig.
Independent Variables*	.86	.74	.72	.77	39.22	.00
Individual Questions**	.91	.83	.78	.70	18.72	.00

Note: *df = 9, 122; p < .001 / **df = 25, 99; p < .001

The alternate hypothesis was accepted confirming that the level of success did vary according to the independent variables. Of the nine independent variables, individual impact was found to be the only significant predictor for organizational impact. The key attributes that pertain to individual impact were change in work patterns and direct benefits. As a model, the independent variables accounted for approximately 74% of the variance in organizational impact, which indicated that it was a relatively strong model to predict success.

A second multiple linear regression test was performed to determine if there were any particular questions that were significant predictors of organizational impact. The variables were replaced with questions and the demographic variables remained the same. The results of the second regression were also significant with $F(25, 99) = 18.72$, $p < .001$), with an R^2 of .83 (Table 7). Ranked from strongest to weakest, questions 8, 23, 24, 21 (negative *t* value), 17, and 20 were found to be the significant predictors for organizational impact. Question 8 was a measure of timeliness and assessed if the SBCT medical information system improved the user's ability to document medical information. Question 23 was a measure of change in work patterns and assessed whether the SBCT had improved the users ability to provide better medical care. Question 24 was the only measure of direct benefits and assessed whether the increased availability to medical information had improved the user's overall performance level. Question 21 was a measure of user friendliness and assessed whether the SCBT medical information system was used more often because it was user friendly. Question 17 was a measure of user satisfaction and assessed if the SBCT medical information system improved medical documentation in fixed medical treatment facilities. The last question, question 20, assessed if medical information in the SBCT medical information system was easier to retrieve than information stored in paper-based records.

Discussion

When reviewing the results, it is important to keep in mind that the Tactical EMR is still in its early stages of development and implementation. The concept for the Tactical EMR was the same for both SBCTs, however, operational constraints affected how each unit used the Tactical EMR and to what capacity. On the whole, the survey respondents evaluated the success of the Tactical EMR and its ability to improve medical documentation relatively low. The mean score

for all five variables fell below 4 on the 7-point Likert scale. The scores, however, should not be overshadowed by the fact that this provides an excellent opportunity to examine critical areas that users felt needed improvement and to discuss confounding factors that influenced both the survey results and the successful implementation of the Tactical EMR.

Information quality, which sought to evaluate the completeness, accuracy, and legibility of medical information, was ranked highest among the variables. Its key attributes of legibility and accuracy of data ranked the highest among all of the respective key attributes evaluated in the study. This indicated that users felt that information within the Tactical EMR was easy to read and understand, that the Tactical EMR had improved the accuracy of medical information, and that the Tactical EMR provided enough information to provide quality patient care.

Organizational impact, the second highest variable, evaluated what impact users felt the Tactical EMR had on the organization. The two areas of evaluation were communication and collaboration and impact on patient care. These attributes measured whether the Tactical EMR had improved communication of medical information from the point of care to higher levels of care, if access to more information had improved continuity of care, if using the Tactical EMR had increased medical documentation, and if the increase in medical documentation had had a positive impact on patient care. Although close, users scored impact on patient care slightly higher than communication and collaboration.

System quality, the third highest variable, evaluated the Tactical EMR's ease of use, response time, and time savings. Time savings was ranked the third highest overall key attribute, which meant that users felt the that the Tactical EMR had, to some degree, improved their ability to document medical information. Ease of use, on the other hand, was ranked among the five lowest key attributes. This indicated that users did not necessarily feel that using the Tactical

EMR to document patient care was easier than previous methods of documentation. It also indicated that users did not necessarily feel that transferring patient encounters between system components was easy. Ease of use did not delineate between use of the Tactical EMR on the battlefield or in fixed medical facilities. As will be discussed later, medics preferred using field medical cards rather than the PIC and BMIS-T because it was quicker, easier, and there were some interface issues. The IOM reports highlight the importance of using information technology to improve patient care. Better access to medical information or past medical history can improve overall quality of care. Documenting medical care may not always be easy, but when done properly, the availability of information can impact future medical care. It is important to educate Tactical EMR users that until easier methods of documentation are developed, it is still vital that patient care be documented in a manner that will provide some sort of longitudinal patient care history. When and where to document the medical care will be operationally dependant and will vary according to each user.

User Satisfaction, the fourth highest variable, sought to evaluate user satisfaction, user friendliness, and attitude toward the Tactical EMR. User satisfaction contained the highest and lowest ranked questions for the survey. A common sentiment among users from both brigades was that the BMIS-T device was not suitable for combat or trauma situations, it was time consuming, non-tactical, fragile, and cumbersome. The interface with the PIC was also questionable. This was confirmed when users scored the question, "the SBCT medical information system improves medical documentation under stressful, fast-paced battlefield conditions" the lowest. As for using the Tactical EMR in garrison, users scored the question, "the SBCT medical information system improves medical documentation in fixed treatment facilities" the highest. Users noted that the field medical card remained the easiest way to

transfer information back to the battalion aid station and that the most appropriate use or place for the Tactical EMR was at the battalion aid station level or higher.

As shown by the results of the multiple linear regression analysis, individual impact, the fifth highest variable, was found to have the greatest influence on organizational impact, or success. The better the medics are able to perform, the better the outcome for the organization. Individual impact evaluated change in work patterns and direct benefits. Both ranked in the bottom five key attributes, indicating that the majority of users felt that the Tactical EMR did not make their job easier nor did it improve their ability to provide better medical care. They also felt that the increase in medical information did not necessarily improve their overall performance level. This is important to note because, on average, despite the Tactical EMR's ability to provide enough information for quality care (accuracy of data); it did not necessarily improve some user's perceived productivity or efficiency levels. There were a select few, however, who consistently used the Tactical EMR and experienced increased productivity and efficiency levels. One example is with the SBCT's imbedded physical therapist. Despite difficulties with the Tactical EMR, the physical therapist religiously used the system, which ultimately allowed him to enhance his ability to provide in-theater care. Access to the ICDB's longitudinal patient record enabled the physical therapist to prevent unnecessary medical evacuations back to the United States saving the unit over 1000 man days during their one year deployment. As shown by the physical therapist, ensuring the Tactical EMR has some value-added benefit for the user is important for increasing usage and improving medical documentation. With few visible benefits or an unclear purpose, users may choose not to continue using the Tactical EMR.

The final variable, usage, was ranked the lowest of the six variables. Usage evaluated number of entries, frequency of use, and duration of use. Despite the users' feelings that the

Tactical EMR enabled them to create and store more patient encounters (number of entries), they did not use it every time they interacted with patients. Users also felt that documenting medical information with the Tactical EMR was not necessarily quicker than documenting information in patient records. Frequency of use and duration of use were ranked the lowest overall key attributes out of the sixteen. The reasons for not using the Tactical EMR varied and like the other variables were influenced by confounding factors. Important confounding factors were identified in the comments section of the survey and during the 3/2 SBCT Tactical e-Medical Record Research and Demonstration Conference. Three commonly noted factors that influenced the success of Tactical EMR and its ability to improve medical documentation were the functioning of the individual system components, connectivity issues, and user training.

The first system component was the PIC, which users from both units found to be unreliable. They were unusable when dirty and they corroded easily. Users also noted that not all of units they supported used the PIC. One important comment and follow-on discussion centered on the exact role of the PIC. Users in 3rd Brigade were unsure if the PIC's primary purpose was for recording immunizations, sick call visits, trauma care, or all of the above.

The second component was BMIS-T. The most resounding comment regarding BMIS-T was that it was impractical in combat and trauma situations. Users felt that BMIS-T was too fragile, cumbersome, non-tactical, and limited in battery power. Once the system's memory became full, the system lagged. The interface with the PIC did not always work and it took too long for the system to start up. Users also indicated that it was hard to download information to the computer, but did not specify if it was CHCS II-T or ICDB. There were mixed reviews about whether there were too many or too few drop down menus. There were also some questions about when to use BMIS-T, at the point of injury or afterwards. One user commented, "Amidst

battlefield conditions, I didn't think of grabbing my system. All I thought about was performing my duties as medic." Ground transport times in Iraq were also quick and did not facilitate good documentation. Therefore, users commented that the field medical card remained the easiest form of medical documentation. Although users felt that the field medical card was the easiest way to document medical patient care, it is not necessarily the most accurate or durable way to record patient care. Field medical cards are limited in the medical information they can provide and they do not often make it through the different levels of medical care. One important medic duty is documenting medical care. Therefore, the key is finding a transparent, yet satisfactory, medium between the most accurate, efficient way to document battlefield medical care and the most durable method for doing so. Users did indicate that BMIS-T was good for sick call and routine care. Sick call and routine care afforded more time to input data and work with the system.

The third system component was CHCS II-T. CHCS II-T is currently deployed in its most rudimentary form and all of the features for the Army's proposed Tactical EMR are not fully operational. According to the 3rd Brigade Surgeon, roughly 50% of the people used CHCS II-T and 50% used ICDB. When CHCS II-T was used, it was used primarily as a decentralized database and the data could only travel as far as the laptops went. 1st Brigade is currently deployed and using CHCS II-T. However, they have had some difficulty keeping it functioning. If users did not use CHCS II-T often, inputting data became difficult and time consuming. One physician noted that accessing notes in CHCS II-T was difficult because the notes were behind too many "non-intuitive" click menus.

The fourth component was ICDB. ICDB streamlines the flow of information and is the crux of the Western Regional Tactical EMR. Users of ICDB found it to be less problematic, easier to

use, and more flexible. Users were able to access past medical histories, and create, save, and manipulate patient notes when needed. Not only did it provide reach-back capability, which allowed physicians in Iraq to review notes from MAMC, it allowed MAMC physicians to review notes created in Iraq. The users were pleased with ICDB and the automation support they received to maintain the Western Regional Tactical EMR's functionality. A major drawback for ICDB was its requirement for internet access.

One of the primary elements crucial to the use of ICDB and the success of the Tactical EMR was connectivity. At all levels of care, the operational environment dictated the availability of resources and units had intermittent internet connectivity. As is traditional with many combat units, the emphasis in the battlefield is the war-fighting effort and those systems that enhance it. Internet connectivity for the SBCT medical personnel was not necessarily a unit priority. This further reaffirmed the users' claims that the Tactical EMR worked well in fixed medical treatment facilities. Command support and leadership awareness of the capabilities of a fully functional Tactical EMR are the keys to ensuring medical personnel get the resources they need. Another important feature of connectivity was how the Tactical EMR was deployed. The SBCTs were the first of the conventional forces to receive a Tactical EMR. Besides improving the medical documentation for their Soldiers, users were limited with what they could do with the electronic information once captured and stored. For example, it was not guaranteed that medical providers above the Stryker Brigade Support Medical Company would have the capability to read the PIC or access updated information from CHCS II-T or ICDB. The result was duplication in work that required users to input everything electronically and then complete paper copies to forward through the higher echelons of medical care. Some users commented

that they knew the medical information would not go anywhere so they saw no reason to continue using the Tactical EMR.

Training was another important factor that influenced the success of the Tactical EMR. Not only was more training needed, but continual training was needed. Survey respondents from 3rd Brigade felt they received little to no training on the how to use the Tactical EMR. This was the result of both pre-deployment training requirements and the rapid fielding of the system. To supplement pre-deployment training, users received small amounts of training while in Iraq and their natural curiosity led them to experiment with the system. However, neither was sufficient for sustained use of the Tactical EMR. Survey respondents from 1st Brigade had more time to train on the equipment, particularly with the ICDB data flow. Comments favored ICDB over CHCS II-T, but comments regarding the PIC and BMIS-T were similar. Both units appeared to be slightly confused over which system was the right system to use, CHCS II-T or ICDB. The lack of training or emphasis on the differences or the importance of the Western Regional Tactical EMR versus the Army's proposed architecture added to the user's confusion and frustration with using the Tactical EMR.

In this study, it was difficult to determine the degree to which the confounding factors affected the users. However, it is important to note that the confounding factors did play, and will continue to play, an important role in evaluating the success of the Tactical EMR. Controlling for and reducing the affects of these confounders will ultimately improve the success of the Tactical EMR. Overall, the results suggest that the Tactical EMR has the ability to improve medical documentation (information quality), but additional emphasis needs to be placed on elements that improve individual impact and usage. The Western Regional Tactical EMR appeared to be favored over the Army's current proposed architecture, especially with 1st

Brigade. It is currently more flexible, user friendly, allows for real-time updates, and provides reach-back capability when internet access is available. Some of its functionality is important to keep in mind as the Army continues to develop the CHCS II-T Tactical EMR. The Western Regional Tactical EMR is an important step in the development of a Tactical EMR for the SBCTs and it is a reliable interim solution until the Army's proposed EMR architecture is complete and fully operational.

Recommendations

The purpose of the study was to evaluate the success of the Western Regional Tactical EMR and its ability to improve medical documentation from the user perspective. Survey results provided important feedback and provided critical insight into specific areas users felt needed improvement. Early identification of the Tactical EMR's strengths and weaknesses allows leadership to correct problems in a timely manner, provides valuable insight for implementation with other units, and ensures Soldiers continue to receive superior medical care.

As the Tactical EMR continues to be developed and improved, there are a few important things to keep in mind. In the article "Evaluating Clinical Information Systems," Kirkley & Rewick (2003) state that a successful clinical information system should think like the user thinks. The Tactical EMR is a variant to the traditional clinical information system, but the concept is the same. In order for the Tactical EMR (both the Western Regional and Army version) to think like the user and promote usage, user needs and the workflow processes must be understood at all levels. Once identified, both must be matched with the system components to ensure the link is supported. "Simply automating existing paper-based processes does not allow the organization to shed inefficiencies" (Kirkley & Rewick, 2003, p. 646).

As identified by the results, the variable ranked lowest for the Tactical EMR was usage. According to Kirkley & Rewick (2003), consistency of design and simplicity are two keys to improving usability or usage. Information must be presented logically and interfaces must be both intuitive and transparent to the user. "Non-intuitive" or inefficient interfaces, as were noted about the PIC, BMIS-T, and CHCS II-T, can lead to dissatisfaction and non-use of the system. Systems that are complex can detract from the mission at hand. In the case of the Tactical EMR, the mission involves both patient care and medical documentation. "A system not designed with usability principles in mind will, at best, not be used and, at worst, will interfere with workflow" (Kirkley & Rewick, 2003, 647).

The 3/2 SBCT Tactical e-Medical Record Research and Demonstration Conference was a great step towards better understanding user needs and workflow processes. It is important that the information gathered at the conference not be forgotten and that it is applied to the next generation of Tactical EMR components. When Soldiers are given a new piece of equipment and are told to make it work, they will do their best. However, they rely upon the subject matter experts and the designers to assist. Continued user feedback and involvement by the designers is crucial to improve the individual system components and for the continued success of the Tactical EMR.

Ongoing training is also paramount for success of the Tactical EMR. Initial training and follow-up support is good, but it is usually not enough. Training for medical personnel must be built into the unit training schedules on a continual basis, especially as the Army's proposed EMR becomes fully operational. Medical personnel must train like they will fight and they must have a complete understanding of the systems they are using and how they are supposed to be used. In addition to hands on training, users must clearly understand the functionality, purpose,

and differences between the Western Regional Tactical EMR and the Army's proposed architecture. "Systems that run from multiple databases often create unnecessary complexity" (Kirkley & Rewick, 2003, 649). It is difficult to predict when the Army's proposed architecture will be fully operational, so delineating the role of each system will help eliminate confusion and reduce unnecessary complexity. It will also help reduce over reliance on the Western Regional Tactical EMR and user resistance to the Army's architecture when it is fully implemented.

Training with the Tactical EMR extends beyond internal unit and user training. Training must simultaneously occur at and with the different echelons of medical care. Users commented that they stopped using the Tactical EMR because higher levels of medical care did not have the same levels of access to the Tactical EMR as they did. It was not guaranteed that higher levels of medical care had PIC readers or access to ICDB and/or CHCS II-T information. Fielding of the Tactical EMR must now extend to higher levels of medical care to promote continued use at lower levels and to fully assess the capabilities of the Tactical EMR throughout the different echelons of medical care. Simultaneous fielding of the Tactical EMR with a combat support hospital, other medical centers, or like units should improve communication and collaboration between the SBCTs and other elements within the military health system. It will allow the units to expand their use and training with the Tactical EMR and will allow them to further train as they will fight on the battlefield.

Perhaps the greatest factor affecting the success of Tactical EMR is command support. Leadership at all levels must fully understand the capabilities of the Tactical EMR and its ability to improve healthcare for Soldiers. The Tactical EMR must be marketed to the combat forces as a direct war fighting system, because to the medical personnel it is. The Tactical EMR provides medical personnel with the battlefield tools to sustain the combat forces. It also provides them

with the tools to provide quality healthcare in a number of operational environments. Command emphasis is important to ensure medical personnel get the resources needed and that they are trained with those resources to operate at maximum capacity. Without a "unit champion," the concept and the operation of the Tactical EMR will not be able to reach its maximum potential.

Conclusion

The development and use of an electronic medical record is the way of the future for both the civilian and military health systems. Over the past year and a half, MAMC, the SBCTs, TMIP, MC4, and TATRC have made significant progress in the development and implementation of a Tactical EMR. Even as this study was being completed, continuous daily improvements have positively impacted the Tactical EMR and its ability to improve quality of care and real-time medical information. This study provides both a quantitative and qualitative evaluation of the success of the Western Regional Tactical EMR and its ability to improve medical documentation. It serves as springboard and model for continued evaluation of the Tactical EMR, especially when 1st Brigade returns from Iraq. The results indicate that Western Regional Tactical EMR is an advantageous interim solution and model for the Army Tactical EMR as it continues to be developed. The results also establish a roadmap which provides leadership with recommended areas of improvement in order to enhance the future implementation of the Tactical EMR. The advances made with the introduction of the Tactical EMR are a step forward in providing a seamless digital healthcare infrastructure and protecting the military's best asset, the Soldier, Sailor, Airman, and Marine.

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Appendix A. Survey Cover Letter

DEPARTMENT OF THE ARMY
WESTERN REGIONAL MEDICAL COMMAND
AND MADIGAN ARMY MEDICAL CENTER
TACOMA, WA 98431-1100

REPLY TO
ATTENTION OF

MCHJ-CS

10 January 2005

MEMORANDUM FOR Medical Personnel Assigned to the 3rd Brigade, 2nd Infantry Division

SUBJECT: Stryker Brigade Combat Team Medical Information System Survey

1. Attached is a survey designed to collect information for a study evaluating the success of the Stryker Brigade Combat Team medical information system, or tactical electronic medical record (tactical EMR), and its ability to improve medical documentation. For this study, the concept of the tactical EMR includes the following components: the personal information carrier (PIC), the Battlefield Medical Information System-Tactical (BMIS-T), CHCS II-Theater, and the Integrated Clinical Database system (ICDB). An honest evaluation of the tactical EMR is important and will provide valuable insight into improving its development and implementation Army wide. The ability to deploy a fully functional tactical EMR will enhance point-of-care treatment, establish a longitudinal health record, improve quality of care, and, ultimately, provide superior health care for our Soldiers. Therefore, I request your assistance in completing the attached survey.

2. The survey has 29 questions and will take less than 10 minutes to complete. When completing the survey, consider the components of the tactical EMR and answer the questions according to your experiences using the medical information system when it was available and working. I encourage you to add comments at the end that you feel are important regarding the system and any suggested improvements. Please answer the questions to the best of your ability. After completing the survey, return it to the person assigned by your unit to collect the surveys. All surveys are anonymous and your input will be combined with other responses. The data will be analyzed to evaluate the success of the tactical EMR and to provide leadership with recommendations for improving its development and implementation.

3. The validity of the results depends on obtaining a high response rate, so I thank you in advance for your time and assistance in completing the survey. If you have questions or would like to submit additional comments, please contact the officer responsible, CPT Scott Stokoe at (253) 968-3226 or scott.stokoe@us.army.mil.

SCOTT J. STOKOE
CPT, MS
Administrative Resident

Appendix B. Approved Survey

SBCT Medical Information System Survey*

* The Medical Information System consists of the Personal Information Carrier (PIC), BMIS-T, CHCS II-T, and ICDB

1 What unit are you assigned to? _____

2 What is your rank? _____

3 What is your current duty position? (circle) Medic PA Physician Admin Other: _____

4 How long have you been assigned with your unit? _____ months

Please rate your agreement or disagreement to the following statements by circling the appropriate number on the scale provided

When the Medical Information System is working and available, I find that...	Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree
5 Using the SBCT Medical Information System to document patient care is easier than previous methods of documentation	1	2	3	4	5	6	7
6 Transferring patient encounters between system components is easy	1	2	3	4	5	6	7
7 The SBCT Medical Information System provides the information I need, when I need it	1	2	3	4	5	6	7
8 The SBCT Medical Information System improves my ability to document medical information	1	2	3	4	5	6	7
9 Medical information is more complete because of the SBCT Medical Information System	1	2	3	4	5	6	7
10 Accuracy of medical information is improved because of the SBCT Medical Information System	1	2	3	4	5	6	7
11 The SBCT Medical Information System provides enough information to provide quality patient care	1	2	3	4	5	6	7
12 Information in the SBCT Medical Information System is easy to read and understand	1	2	3	4	5	6	7
13 The SBCT Medical Information System has enabled me to create and store more patient encounters	1	2	3	4	5	6	7
14 I use the SBCT Medical Information System every time I interact with a patient	1	2	3	4	5	6	7
15 Documenting medical information in the SBCT Medical Information System is quicker than documenting information in paper records	1	2	3	4	5	6	7
16 The SBCT Medical Information System improves medical documentation under stressful, fast-paced battlefield conditions	1	2	3	4	5	6	7
17 The SBCT Medical Information System improves medical documentation in fixed medical treatment facilities	1	2	3	4	5	6	7
18 The SBCT Medical Information System is an improvement over paper-based records	1	2	3	4	5	6	7
19 The SBCT Medical Information System is worth the time and effort required to use it	1	2	3	4	5	6	7
20 Medical information stored in the SBCT Medical Information System is easier to retrieve than information stored in paper-based records	1	2	3	4	5	6	7
21 I use the SBCT Medical Information System more often because it is user friendly	1	2	3	4	5	6	7
22 The SBCT Medical Information System has made my job/mission easier	1	2	3	4	5	6	7
23 The SBCT Medical Information System has improved my ability to provide better medical care	1	2	3	4	5	6	7
24 The increased availability of medical information has improved my overall performance level	1	2	3	4	5	6	7
25 The SBCT Medical Information System has improved the communication of medical information from the point-of-care to higher levels of care	1	2	3	4	5	6	7
26 Access to more medical information has improved the continuity of care for patients	1	2	3	4	5	6	7
27 Using the SBCT Medical Information System has increased medical documentation within my unit	1	2	3	4	5	6	7
28 The increase in medical documentation has had a positive impact on patient care	1	2	3	4	5	6	7
29 I believe the implementation of the SBCT Medical Information System is progressing in the right direction	1	2	3	4	5	6	7

Comments (If needed, please continue your comments on the back of this sheet):

Appendix C. Questions Associated with Each Variable and Key Attribute

Question	Variable	Key Attributes
	System Quality	
5	Using the SBCT Medical Information System to document patient care is easier than previous methods of documentation	Ease of Use
6	Transferring patient encounters between system components is easy	Ease of Use
7	The SBCT Medical Information System provides the information I need, when I need it	Response Time
8	The SBCT Medical Information System improves my ability to document medical information	Timesavings
	Information Quality	
9	Medical information is more complete because of the SBCT Medical Information System	Completeness
10	Accuracy of medical information is improved because of the SBCT Medical Information System	Accuracy of Data
11	The SBCT Medical Information System provides enough information to provide quality patient care	Accuracy of Data
12	Information in the SBCT Medical Information System is easy to read and understand	Legibility
	Usage	
13	The SBCT Medical Information System has enabled me to create and store more patient encounters	Number of Entries
14	I use the SBCT Medical Information System every time I interact with a patient	Frequency of Use
15	Documenting medical information in the SBCT Medical Information System is quicker than documenting information in paper records	Duration of Use
	User Satisfaction	
16	The SBCT Medical Information System improves medical documentation under stressful, fast-paced battlefield conditions	User Satisfaction
17	The SBCT Medical Information System improves medical documentation in fixed medical treatment facilities	User Satisfaction
18	The SBCT Medical Information System is an improvement over paper-based records	User Satisfaction
19	The SBCT Medical Information System is worth the time and effort required to use it	Attitude
20	Medical information stored in the SBCT Medical Information System is easier to retrieve than information stored in paper-based records	User Friendliness
21	I use the SBCT Medical Information System more because it is user friendly	User Friendliness
	Individual Impact	
22	The SBCT Medical Information System has made my job/mission easier	Change in Work Patterns
23	The SBCT Medical Information System has improved my ability to provide better medical care	Change in Work Patterns
24	The increased availability of medical information has improved my overall performance level	Direct Benefits
	Organizational Impact	
25	The SBCT Medical Information System has improved the communication of medical information from the point-of-care to higher levels of care	Communication / Collaboration
26	Access to more medical information has improved the continuity of care for patients	Impact on Patient Care
27	Using the SBCT Medical Information System has increased medical documentation within my unit	Impact on Patient Care
28	The increase in medical documentation has had a positive impact on patient care	Impact on Patient Care
29	I believe the implementation of the SBCT Medical Information System is progressing in the right direction	

Appendix D. Descriptive Statistics by Unit

	All Surveys			3rd Brigade			1st Brigade		
Variable	n	Mean	Standard Deviation	n	Mean	Standard Deviation	n	Mean	Standard Deviation
Months Assigned	134	25.75	13.97	90	28.32	14.81	44	20.48	10.34
Question									
5	134	2.95	1.59	90	3.06	1.60	44	2.73	1.55
6	135	3.06	1.52	90	3.11	1.59	45	2.96	1.38
7	134	3.33	1.51	90	3.38	1.53	44	3.23	1.48
8	135	3.57	1.67	90	3.53	1.68	45	3.64	1.68
9	135	3.43	1.64	90	3.23	1.56	45	3.82	1.75
10	134	3.51	1.55	90	3.37	1.54	44	3.80	1.55
11	135	3.71	1.48	90	3.70	1.53	45	3.73	1.39
12	135	3.75	1.60	90	3.67	1.61	45	3.91	1.59
13	134	3.45	1.62	89	3.20	1.51	45	3.93	1.72
14	135	2.80	1.71	90	2.58	1.61	45	3.24	1.82
15	135	2.68	1.65	90	2.93	1.70	45	2.18	1.44
16	135	2.43	1.56	90	2.54	1.55	45	2.20	1.58
17	134	4.08	1.69	90	3.87	1.66	44	4.52	1.66
18	134	3.49	1.56	89	3.48	1.58	45	3.49	1.55
19	135	3.27	1.62	90	3.30	1.60	45	3.20	1.66
20	135	3.67	1.69	90	3.40	1.62	45	4.22	1.72
21	133	2.83	1.45	88	2.86	1.45	45	2.76	1.46
22	135	2.95	1.50	90	3.00	1.53	45	2.84	1.46
23	134	3.04	1.54	89	3.07	1.54	45	2.98	1.57
24	135	3.10	1.52	90	3.09	1.54	45	3.11	1.48
25	134	3.28	1.65	90	3.17	1.62	44	3.52	1.72
26	133	3.55	1.62	88	3.36	1.62	45	3.91	1.56
27	134	3.24	1.52	89	3.11	1.46	45	3.49	1.62
28	135	3.38	1.59	90	3.20	1.52	45	3.73	1.68
29	135	3.79	1.72	90	3.97	1.78	45	3.44	1.56
Key Attribute									
Ease of Use	135	3.00	1.45	90	3.08	1.51	45	2.84	1.33
Response Time	134	3.33	1.51	90	3.38	1.53	44	3.23	1.48
Timesavings	135	3.57	1.67	90	3.53	1.68	45	3.64	1.68
Completeness	135	3.43	1.64	90	3.23	1.56	45	3.82	1.75
Accuracy of Data	135	3.61	1.40	90	3.53	1.43	45	3.78	1.34
Legibility	135	3.75	1.60	90	3.67	1.61	45	3.91	1.59
Number of Entries	134	3.45	1.62	89	3.20	1.51	45	3.93	1.72
Frequency of Use	135	2.80	1.71	90	2.58	1.61	45	3.24	1.82
Duration of Use	135	2.68	1.65	90	2.93	1.70	45	2.18	1.44
user satisfaction	135	3.33	1.33	90	3.30	1.38	45	3.39	1.22
Attitude	135	3.27	1.62	90	3.30	1.60	45	3.20	1.66
User Friendliness	135	3.27	1.41	90	3.16	1.46	45	3.49	1.30
Change in Work Patterns	135	2.99	1.43	90	3.03	1.45	45	2.91	1.39
Direct Benefits	135	3.10	1.52	90	3.09	1.54	45	3.11	1.48
Communication/Collaboration	134	3.28	1.65	90	3.17	1.62	44	3.52	1.72
Impact on Patient Care	135	3.39	1.45	90	3.24	1.41	45	3.71	1.49
Variable									
System Quality	135	3.31	1.38	90	3.33	1.43	45	3.26	1.31
Information Quality	135	3.60	1.40	90	3.48	1.43	45	3.84	1.33
Usage	135	2.98	1.37	90	2.91	1.41	45	3.12	1.29
User Satisfaction	135	3.29	1.35	90	3.25	1.39	45	3.36	1.25
Individual Impact	135	3.04	1.40	90	3.06	1.45	45	3.01	1.33
Organizational Impact	135	3.35	1.47	90	3.20	1.44	45	3.64	1.49

Appendix E. Ranking of Variables and Key Attributes by Demographic Category

	Overall	Unit		Rank			Duty Position		Time with Unit		
Variable and Key Attribute	All Surveys	3rd Brigade	1st Brigade	Enlisted	NCO	Officer	Physician / Admin	Medic	0 - 12 Months	12 - 24 Months	24 + Months
System Quality	**3**	**2**	**4**	**2**	**5**	**3**	**3**	**3**	**5**	**2**	**2**
Ease of Use	13	13	15	12	14	14	15	13	15	12	13
Response Time	7	4	11	2	12	9	8	6	12	5	6
Timesavings	3	2	6	3	3	4	5	3	5	3	3
Information Quality	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Completeness	5	8	3	5	8	1	1	7	2	4	10
Accuracy of Data	2	3	4	4	2	2	2	2	6	2	2
Legibility	1	1	2	1	1	3	3	1	3	1	1
Usage	**6**	**6**	**5**	**5**	**6**	**5**	**5**	**6**	**3**	**6**	**6**
Number of Entries	4	9	1	6	4	5	4	4	1	7	4
Frequency of Use	15	16	10	15	16	10	11	16	7	16	16
Duration of Use	16	15	16	16	15	16	16	15	16	15	15
User Satisfaction	**4**	**3**	**3**	**4**	**3**	**4**	**4**	**4**	**4**	**3**	**3**
User Satisfaction	8	5	9	10	6	7	7	9	10	8	5
Attitude	10	6	12	11	9	13	13	10	13	10	8
User Friendliness	11	11	8	7	11	8	10	11	9	9	11
Individual Impact	**5**	**5**	**6**	**6**	**4**	**6**	**6**	**5**	**6**	**5**	**5**
Change in Work Patterns	14	14	14	14	13	15	14	14	14	14	14
Direct Benefits	12	12	13	13	10	11	9	12	11	13	12
Organizational Impact	**2**	**4**	**2**	**3**	**2**	**2**	**2**	**2**	**2**	**4**	**4**
Communication/Collaboration	9	10	7	8	7	12	12	8	4	11	8
Impact on Patient Care	6	7	5	9	5	6	6	5	8	6	7

Appendix F. Spearman Rho Correlation Analysis for Variables

	System Quality	Information Quality	Usage	User Satisfaction	Individual Impact	Organizational Impact	Duty Position	Unit	Time with Unit	Rank
System Quality	1	.80(**)	.78(**)	.84(**)	.77(**)	.69(**)	.04	-.03	-.17	-.14
Information Quality	.80(**)	1	.74(**)	.76(**)	.73(**)	.72(**)	.10	-.01	-.24(**)	.04
Usage	.78(**)	.74(**)	1	.79(**)	.76(**)	.69(**)	.03	.02	-.31(**)	-.10
User Satisfaction	.84(**)	.76(**)	.79(**)	1	.86(**)	.73(**)	.10	.03	-.18(*)	-.10
Individual Impact	.77(**)	.73(**)	.76(**)	.86(**)	1	.79(**)	.07	.01	-.18(*)	-.06
Organizational Impact	.69(**)	.72(**)	.69(**)	.73(**)	.79(**)	1	.04	.02	-.25(**)	-.04
Duty Position	.04	.10	.03	.10	.07	.04	1.00	.03	-.08	.17
Unit	-.03	-.01	.02	.03	.01	.02	.03	1.00	-.05	-.09
Time wth Unit	-.17	-.24(**)	-.31(**)	-.18(*)	-.18(*)	-.25(**)	-.08	-.05	1	.05
Rank	-.14	.04	-.10	-.10	-.06	-.04	.17	-.09	.05	1

Note: N= 132; ** $p < .01$ (2-tailed); $p < .05$ (2-tailed)

Appendix G. Independent-Samples *t*-test for Unit and Duty Position

Variable	Unit		Duty Position	
	t	Sig.	t	Sig.
System Quality	.30	.77	-.34	.74
Information Quality	-1.41	.16	1.01	.32
Usage	-.84	.40	.14	.89
User Satisfaction	-.44	.66	-.40	.69
Individual Impact	.18	.86	-.41	.68
Organizational Impact	-1.67	.10	-.11	.92

Note: N = 133; alpha = .05

Appendix H. Analysis of Variance for Rank Groups

Variable		Sum of Squares	Mean Square	F	Sig.
System Quality	Between Groups	1.62	.81	.42	.66
	Within Groups	248.51	1.93		
	Total	250.13			
Information Quality	Between Groups	2.33	1.16	.60	.56
	Within Groups	254.31	1.97		
	Total	256.64			
Usage	Between Groups	.32	.16	.10	.92
	Within Groups	242.67	1.88		
	Total	242.67			
User Satisfaction	Between Groups	.22	.11	.10	.94
	Within Groups	237.97	1.85		
	Total	237.97			
Individual Impact	Between Groups	1.65	0.83	.41	.66
	Within Groups	259.74	2.01		
	Total	261.39			
Organizational Impact	Between Groups	.53	.27	.12	.89
	Within Groups	279.98	2.17		
	Total	279.98			

Note: df= 2,129; alpha = .05